

Reprioritization of Research for Combat Casualty Care

COL James R. Ficke, MD
William T. Obremskey, MD,
MPH
LCDR Robert J. Gaines, MD
COL Paul F. Pasquina, MD
Michael J. Bosse, MD
LCDR Christiaan N. Mamczak,
DO
Robert V. O'Toole, MD
Kristin R. Archer, PhD
Christopher T. Born, MD
CDR Mark E. Fleming, DO,
MC, USN
J. Tracy Watson, MD
Lt Col Wade T. Gordon, MD
James P. Stannard, MD
Col Damian M. Rispoli, MD
Ellen J. MacKenzie, PhD
Joseph C. Wenke, PhD
Joseph R. Hsu, MD
Andrew N. Pollak, MD
COL Romney C. Andersen, MD,
USA

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Abstract

Since the beginning of the conflicts in Iraq and Afghanistan more than a decade ago, much has been learned with regard to combat casualty care. Although progress has been significant, knowledge gaps still exist. The seventh Extremity War Injuries symposium, held in January 2012, reviewed the current state of knowledge and defined knowledge gaps in acute care, reconstructive care, and rehabilitative care in order to provide policymakers information on the areas in which research funding would be the most beneficial.

In 2005, military orthopaedic surgeons worked with the American Academy of Orthopaedic Surgeons to establish the first Extremity War Injuries (EWI) symposium. This scientific meeting was convened to critically evaluate the then-current state of science and to assess gaps in knowledge and treatment of the complex injuries sustained by US military combat personnel serving in Iraq and Afghanistan. The goals of that first meeting, held in January 2006, were to acquire mutual understanding of the challenges associated with wartime injuries, develop a research agenda and outline future research questions, highlight opportunities for future research funding, and publish a supplement in conjunction with the *Journal of the American Academy of Orthopaedic Surgeons*.

The meeting included several sessions on the then-current challenges involved in managing these severe injuries, followed by focused breakout sessions designed to capture expert perspective on these knowledge gaps. These perspectives were used to develop a prioritized list of areas in which research funding might best be focused: data collection system, timing of treatment, débride-

ment techniques, transport issues, coverage issues, antibiotic treatment, management of segmental bone defects, development of an animal model to study blast injuries, issues related to amputee care, and heterotopic ossification. The two additional recommendations that were made included the development of a joint civilian/military advisory board and development of an extremity war injuries course.

Since 2006, Congress has directed more than \$200 million to fund research to address the difficult clinical challenges in caring for wounded warriors.¹ The research funding was provided through a rigorous competitive peer-reviewed process by the Congressionally Directed Medical Research Program, the US Army Medical Research and Materiel Command, and the US Army Institute of Surgical Research. As a result of this funding, many of the original knowledge gaps have been adequately addressed and ongoing studies developed to address the remaining needs.

In the panels convened at the 2012 EWI symposium, Extremity War Injuries VII: A Decade at War: Evolution of Orthopaedic Combat Casualty Care, orthopaedic surgeons,

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physical medicine and rehabilitation specialists, physical and occupational therapists, pain medicine experts, psychologists, and epidemiologists decided on current research gaps for potential future funding. The first session examined front-line (ie, acute) care provided by deployed surgeons, the second reviewed definitive reconstructive care, and the third focused on long-term rehabilitation services provided by physicians and therapists.

Acute Care Research Priorities

A decade of war has provided ample opportunity to identify research op-

portunities with regard to acute management of combat injuries. There is no doubt that numerous lives have been saved as a result of previous research and the successful implementation of lessons learned regarding early hemostasis, triage and evacuation of wounded soldiers, wound management, and infection prevention. However, there is room for improvement to maximize the care of our wounded warriors. Acute combat casualty care research needs and priorities were developed at the EWI VII meeting.

Areas of interest for early hemorrhage control and injury prevention included the development of mechanisms to obtain junctional large ves-

sel control in the groin and axilla, as well as better defining the limits and effectiveness of prolonged tourniquet use with regard to long-term limb function and amputation levels. Further investigation of the use and value of protective undergarments is needed to help prevent urogenital injuries, especially in the case of the dismounted complex blast injury. Similarly, analysis on early medevac utilization of pelvic binders is warranted for casualties who present with shock and pelvic injuries.

Opportunities for improvement in early wound management were also addressed. Although open wounds are common in combat injuries, there is room for improvement in

From the Department of Orthopaedics and Rehabilitation (Dr. Ficke, Dr. Rispoli, and Dr. Hsu) and the US Army Institute of Surgical Research (Dr. Wenke), San Antonio Military Medical Center, Fort Sam Houston, TX, the Uniformed Services University of the Health Sciences, Bethesda, MD (Dr. Ficke, Dr. Pasquina, Dr. Fleming, Dr. Gordon, Dr. Rispoli, Dr. Hsu, and Dr. Andersen), the Department of Orthopaedics and Rehabilitation, Vanderbilt University Medical Center, Nashville, TN (Dr. Obremskey and Dr. Archer), Walter Reed National Military Medical Center, Bethesda, MD (Dr. Pasquina, Dr. Fleming, Dr. Gordon, and Dr. Andersen), the Department of Orthopaedic Surgery, Naval Medical Center Portsmouth, VA (Dr. Gaines and Dr. Mamczak), the Department of Orthopaedics, Carolinas Medical Center, Charlotte, NC (Dr. Bosse), the Department of Orthopaedics, University of Maryland School of Medicine, Baltimore, MD (Dr. O'Toole and Dr. Pollak), the Department of Orthopaedics, Warren Alpert Medical School, Brown University, Providence, RI (Dr. Born), the Department of Orthopaedic Surgery, Saint Louis University, Saint Louis, MO (Dr. Watson), Missouri Orthopaedic Institute, University of Missouri, Columbia, MO (Dr. Stannard), and the Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD (Dr. MacKenzie).

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formal training and surgeon education in proper techniques of early wound débridement. In addition, better scientific data are needed on the differences between negative-pressure wound therapy and bead pouches, as well as on other mechanisms of local antibiotic delivery.

Infection prevention is a third critical area of importance in acute care research. The effect of high-dose oxygen use on combat wounds in the perioperative period, the use of silver-coated implants, and systemic antibiotic type and duration are other areas of interest.

Based on this information, the panel outlined the top six priorities for acute care research: (1) junctional control of hemorrhage, (2) high-dose oxygen use in the early perioperative period, (3) effectiveness of local antibiotic delivery systems (ie, beads, gels, nanotechnology), (4) effectiveness of negative-pressure wound therapy versus bead pouch, (5) pelvic binder in buddy care and early transport, and (6) education on and effectiveness of surgical débridement techniques.

Reconstructive Care Research Priorities

Review of previous research in definitive reconstruction and assessment of the current knowledge gaps revealed several areas for further study. Reduction of complications after reconstruction with an emphasis on surgical site infection remains a key area of focus. Local adjuncts to reduce infection intraoperatively, such as antibiotic powders, gels, and colloids, deserve further investigation, as do systemic treatments such as perioperative oxygen and optimization of prophylactic and therapeutic antibiotics. Models to predict risk of complication are needed to aid clinician decision making. Techniques to

better understand and potentially improve modifiable risk factors for complication (eg, smoking, nutrition) are needed, as well.

Advances in wound management technology have improved our ability to effectively manage larger wounds in a staged fashion, but many issues remain unresolved. Optimum timing and the development of new closure techniques require further research. Focused investigation of the healing milieu of the wound bed and markers of angiogenesis may be exploited to indicate when a wound is healthy and suitable for closure. The ideal timing of fracture repair is still unknown, as is when a wound should be considered clean and the ideal timing of definitive soft-tissue coverage. The ideal type of soft-tissue coverage is unknown, as well. Techniques and experience in wound débridement, closure, and flap coverage should be explored to determine how factors—including surgeon experience—affect the outcomes of limb salvage. This will help in tailoring educational opportunities for surgeons and institutionalizing effective technique aimed at maximizing salvage outcomes.

Techniques to reconstruct segmental bone and soft-tissue loss are improving, but by no means is the ideal technique known or validated. Effectiveness and proper management of biologic membranes using the Masquelet technique should be defined. Additionally, better definition is needed of the most effective type of and pore size for the antibiotic spacer used in this technique, along with the cellular basis of biologic activity within the created membrane, cell recruitment, and maturation of the created membrane.

The traumatic behavior of nerves as well as their regeneration and potential for repair or transfer requires greater attention. Successful nerve transfer to functional motor units

may provide more rapid and robust recovery than do current methods of nerve grafting. Traumatic nerve defects continue to be sources of severe functional incapacity.

Finally, significant research is required into the causes and mediators of posttraumatic arthritis. Little is known about the recovery of chondrocytes, the recovery of the subchondral plate, and restoration of the synovial fluid after high-energy periarticular injury. These commonly debilitating sequelae of periarticular fractures have a significant detrimental effect on long-term recovery and function of combat-wounded personnel. Posttraumatic arthritis is the leading cause of lost duty and the foremost reason for early discharge from service. This condition also greatly affects the ability of wounded warriors to lead active, pain-free lives after completing their service. Animal models and basic clinical studies are needed.

Based on this information, the panel outlined the top seven priorities for reconstructive care research: (1) Masquelet technique for bioactive membrane formation and techniques for managing segmental defects, (2) reduction of surgical site infection through local (ie, antibiotic gels, powders, colloids) or systemic treatment, (3) studies of the wound bed environment, (4) timing of wound closure and flap coverage, (5) education in débridement and soft-tissue coverage, (6) nerve grafts or transfers, and (7) posttraumatic osteoarthritis.

Rehabilitation Research Priorities

Although the importance of rehabilitation following orthopaedic trauma to promote functional recovery, independence, and quality of life is widely accepted, evidence to support

the correct choice among the variety of rehabilitation interventions is largely empiric. This is particularly true when treating combat casualties. State-of-the art military rehabilitation programs have been well described in the *Textbooks of Military Medicine: Care of the Combat Amputee*.² However, many of the espoused rehabilitation protocols were developed by consensus opinion rather than rigorous scientific methodology. Contributing to the challenges in adequately studying the effectiveness of rehabilitation interventions are the lack of well-defined and validated outcome measures, the heterogeneity of injury patterns, and the multitude of factors that likely influence outcomes (eg, anatomic, physiologic, psychosocial, cultural).

Given the complexity of the injuries currently sustained by war casualties, increasing challenges exist in optimizing rehabilitation, recovery, and reintegration. Today it is not uncommon for a war casualty to survive massive head trauma, multiple extremity loss, significant soft-tissue injury, and sensory loss as the result of a blast injury. This type of injury pattern, coupled with associated behavioral health problems such as posttraumatic stress disorder, depression, and/or anxiety and the coexistence of debilitating pain syndromes, presents significant challenges to rehabilitation professionals. Furthermore, advances in technology, particularly in prostheses, orthoses, and other assistive technologies, present unprecedented opportunities to expand rehabilitation to help injured service members achieve the highest level of physical and emotional recovery.

Symposium participants examined the most challenging rehabilitation issues facing injured service members with regard to short- and long-term

recovery. Particular emphasis was given to extremity-related trauma because it is the leading source of medically disabling conditions and unfitness for continued service. Other groups within the Department of Defense (DOD) and Department of Veterans Affairs (DVA) are already examining issues such as improving pain management, prosthetic and orthotic development, and spinal cord and traumatic brain injury; thus, these topics were not discussed in detail.

The panel determined the top seven priorities for rehabilitation-related research to be (1) physical therapy (ie, comparative effectiveness studies); (2) improving our understanding of resilience; (3) developing strategies to enhance self-efficacy, motivation, and recovery; (4) elucidation of the negative effects of immobility; (5) joint stiffness and contracture of the ankle, knee, and elbow; (6) long-term complications of disability secondary to posttraumatic arthritis; and (7) long-term complications in the amputee as well as in limb-salvage populations.

The panel also unanimously agreed that further investment should be made in the development of rehabilitation-related research infrastructure within military treatment facilities. Members cited the importance of obtaining continued support for The Center for Rehabilitation Sciences Research at the Uniformed Services University of the Health Sciences and leveraging civilian partnerships through the Bridging Advanced Developments for Exceptional Rehabilitation (BADER) Consortium at the University of Delaware and the Major Extremity Trauma Research Consortium (METRC), which is coordinated through the Johns Hopkins Bloomberg School of Public Health. Finally, the panel recognized

the continued need for data integration across the DOD and DVA to facilitate improved population-based research and long-term outcome studies.

Summary

The prioritized research objectives identified 6 years ago at EWI I formed the nucleus of major efforts toward advancing our understanding and management of the severe extremity injuries sustained in modern combat. These objectives have received more attention over the course of the first seven EWI symposia than ever before. Much remains to be studied, and the evaluation from the expert panels convened at EWI VII in January 2012 demonstrates that progress has already been made or is actively under way in several areas. Future progress will require comparative effectiveness studies and validation of techniques that are still being translated into practice. The greatest efforts must be focused on validation of additional acute hemorrhage control, the development of clinical trials for segmental defects of bone and soft tissue, and the study of outcomes of various rehabilitation efforts to restore limb function, reduce posttraumatic arthritis, and mitigate posttraumatic complications.

References

1. Congressionally Directed Medical Research Programs: *Funding History*. Washington, DC, US Department of Defense, 2012. Available at: <http://cdmrp.army.mil/about/fundinghistory.shtml>. Accessed June 21, 2012.
2. Walter Reed Army Medical Center Borden Institute: *Textbooks of Military Medicine: Care of the Combat Amputee*. Washington, DC, Department of the Army, 2010.